



# Coal



The Coal we burn today. . .



... came from these giant forests  
of the Carboniferous age—between  
200 and 300 million years ago.

P. 8 - C



Can you recognize the different  
species of plants and animals?  
All of them are now extinct, but  
smaller related species will be  
familiar to you.

# part one

## Mining for coal



Fossilized ferns found in coal-measures.

*The Age of the Great Ferns* – Between 200 and 300 million years ago, the climate of the Northern Hemisphere was warm and wet. The land was covered with dense tropical forests. For century after century, plants – mostly mosses and huge ferns – grew and reproduced and died. The dead plants formed a layer of decaying vegetable matter – often many feet thick. This became the coal we know today.

Sand and mud, washed down by rivers, covered the vegetable sludge. More trees grew on top; they died and were covered in their turn. This happened many times.

Eventually these 'sandwiches' of mud, sand, and vegetable matter were overlaid with rock, sometimes thousands of feet thick. It was the period called the *Carboniferous Age* – the age of the birth of coal.

The weight of the rock pressed the moisture out of the sludge and, thanks to the heat at the great depth at which the layers were buried, turned the vegetation into coal. The sand became sandstone and the mud became shale. So twenty feet of rotting vegetation became about one foot of coal.

Plants need sugar-like substances to grow. They make these substances by using carbon dioxide (from the air) and water as raw materials. The energy comes from the sunlight which falls on the plant leaves. When the plants from the Carboniferous forests decayed to form coal, only a little of this energy was released; when coal is burnt in air, all the rest of the energy is given out. Thus, the energy we get from coal came originally from the sun.

*Distribution* – In the British Isles, the chief coal measures are found in four areas: in Scotland, the north of England, South Wales, and the Midlands which is the largest area of all. There is also coal in Kent. The Carboniferous Age ended

COUNTY & Sheet Number or N.G. Number Durham 19 N.W.		Ref. No. 61			
NAME OF BORE BORE CHARLAW Colliery Date 6.12.59 Starting Level +6					
Description of Bore Surface 134					
Principal Horizons	Log	Seam Sections & Depths to Important Horizons			
ft	ft	Dip Dev Oil Gas Water	Electric Log	Coring	Casing Left in hole
0	12				
50		C. 24° at 37'		T	
100			Dp 4°		
150		C. 72° at 111'		0	0
200		C. 36° at 195'	Dp 5° Dn 1°		
250		C. 37° at 258'			
300		C. 70° at 277'			
315			W.F. Dn 1°		34
350		Total Depth	OS		0' 285 8
DETAILS OF FINAL SEALING					
CORE RECOVERY					
REMARKS					
		Shale			
		Sandstone			
		Grit			

Geologists make bore-holes in the ground to discover the location of coal seams. Here is a chart prepared by a geologist showing rock units and coal seams and the depths at which they have been found.

with a great upheaval of the rocks. The large coalfields were subsequently broken down by buckling into about forty smaller areas.

Coal often lies in the shape of a shallow basin. Where the edges of the basin reach the surface, the coalfield is said to be exposed. British coalfields, except those in Kent, come near or meet the surface. About 200 million tons of coal are mined in Britain every year. Altogether, the coal-producing areas of the world produce about 2,700 million tons a year – over ten times as much.

*Some British seams* – All worked coal seams have names. Many simply describe the thickness of the coal, like the Yard seam in Northumberland, the Two Foot of Fife, and the Nine Foot of Warwickshire; others are named after places, like the Busty of Durham and the Beeston of Yorkshire; and some are named after people, like the Hutton of Durham and the Hughes of South Wales.

Some seams are very thick; in Britain, thirty feet is about the maximum, but in China they may be over a hundred feet thick. Other seams are very thin, less than twelve inches. Some are horizontal, like the Top Hard of Nottingham which becomes the Barnsley Bed in Yorkshire. Some slope steeply, like the Banbury of North Staffordshire. The Stinking Seam of Leicestershire is so called because of its high sulphur content. One seam in Scotland produces the 'Parrot' coals which make crackling, parrotlike noises when they burn. Some coals are mined near to the surface; others at depths of more than half a mile.

*Kinds of coal* – There are two distinct kinds of coal: the older bituminous coal, which is black and hard; and the

Coal outcrop in the cliffs at Newbiggin-by-the-Sea in Northumberland. The outcrop is a black seam about half way up the cliff; streaks in the unbroken line across the cliff face.



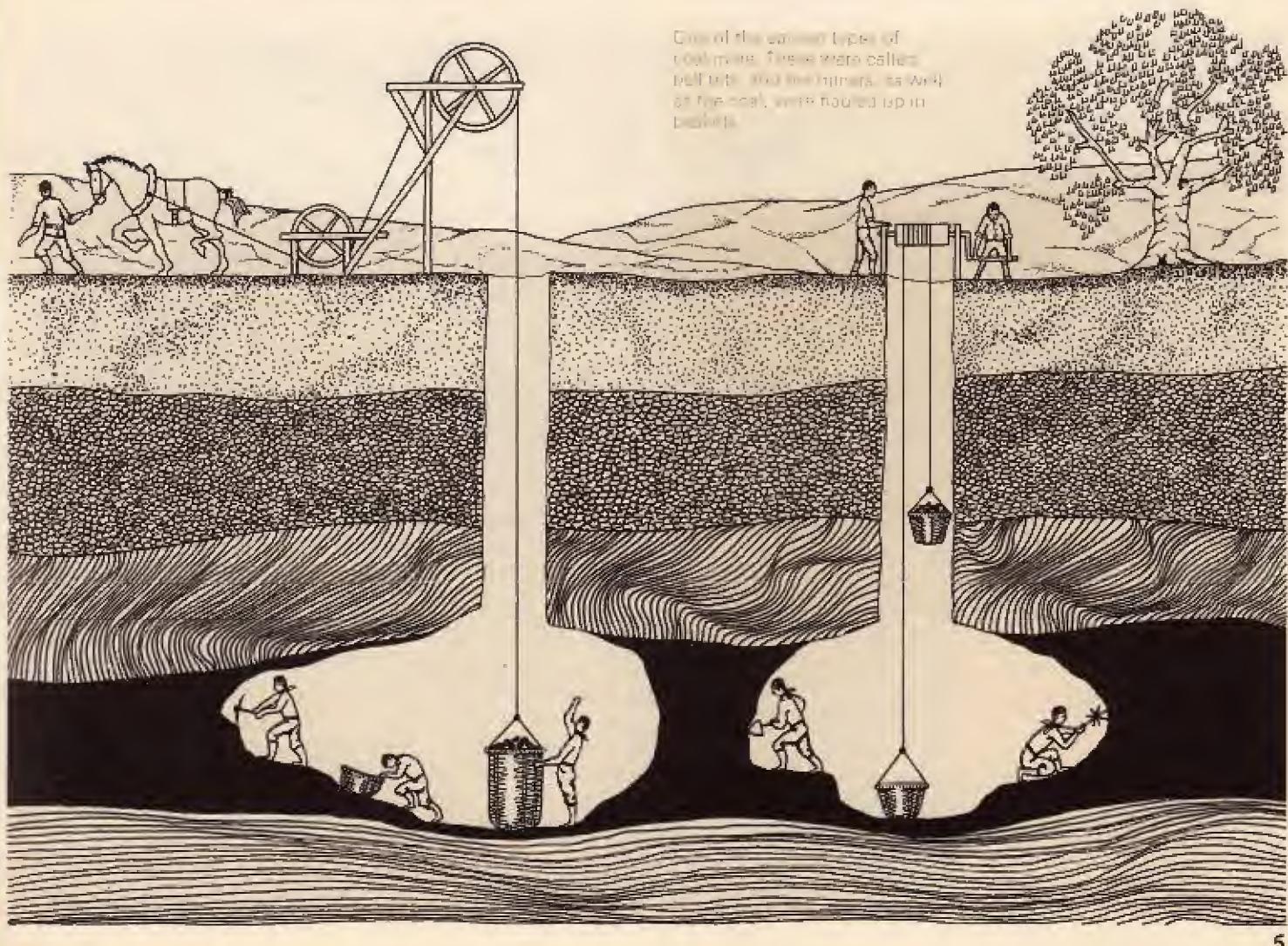
younger brown coal, which is soft. Nearly all British coal is hard: the only brown coal is in tiny deposits at Bovey Tracy in Devon. But there are many different kinds of hard coal. All of them are black but their appearance differs on closer examination. So does their quality. Some coals are very hard and clean to touch; others are softer and crumble easily.

All kinds of coal contain carbon, hydrogen, and oxygen in varying proportions. They contain small amounts of nitrogen and sulphur too, although seldom more than one or two per cent. Welsh anthracite, for example, may contain 95 per cent or more of carbon and burn almost without flame, whereas coal from Leicestershire may contain less than 80 per cent of carbon and produce a lot of flame and smoke. As a rule, the higher the content of carbon, the less smoke is given off.

*Coal in the past* – Coal has been used for thousands of years. The Romans used it during their occupation of Britain 2,000 years ago. The first people in this country to burn coal most probably gathered it where the seams rose and 'outcropped' at the surface, especially by the seaside. Until the seventeenth century, most of the coal mined in Britain was known as sea coal, partly because it was brought by sea from the north-east coast, but also because it was found by the sea shore in Northumberland and in Fifeshire. The monks of Tynemouth were among the first to mine coal, probably some thousand years ago; there is evidence that it was shipped from Tynemouth in 1269. But mining was also going on in Shropshire, Leicestershire, Yorkshire, and South Wales. In 1257 Queen Eleanor objected to the use of coal in Nottingham because of the smoke, and in the same year payments were made by the King's Exchequer for coal used in forging iron at Westminster Palace. Smiths, limeburners, and brewers began to use it. In 1306 Edward I tried to get the smiths to burn wood instead, but his royal proclamation was often ignored because coal was cheaper.

Coal was not everywhere popular, and it only became acceptable as a fuel when chimneys were built to remove the smoke. The first chimneys began to appear in the fourteenth century. Made of iron, they were movable and designed to take the smoke from just above the fire in the centre of the room to a hole in the roof. Later chimneys were built of stone, either in the rear wall of the hall or at the ends of cottages, sometimes even outside.

An important shipping trade from the Tyne grew up in the fifteenth century. Coal was moved in a 'chaldron', a basket-shaped container holding about 2,000 lb, and the ships used to carry twenty chaldrons. When the King put a tax of twopence on each chaldron, the exporters increased its size to pay less tax; the King's Commissioners then started to drive long nails into the bow and stern of each boat to prevent this evasion of tax and also to avoid overloading. This was the earliest known method of fixing the Load Line; the Plimsoll Line came much



later. But the chaldron went on increasing in size and finally held 53 hundredweight.

Queen Elizabeth did not like coal smoke, but she was succeeded by James I who was accustomed to having a coal fire in his Fifeshire palace. He introduced coal fires into his new Westminster home and coal became more fashionable. Until then it had been used by the more humble artisans and others who could not afford to buy wood. By the middle of the sixteenth century forests were being cut down for timber so quickly that the Government became worried and had to make

laws to restrict wood-burning: this resulted in a greater use of coal.

Miners in the sixteenth century were paid threepence or fourpence a day (at that time a reasonable wage), but usually they had to pay for their own tools – 2s 6d for a winding rope and twopence for a winding windlass. The picks with which they cut the coal were so dear (because of the high cost of iron) that these were often hired out and paid for by the year.

*The Industrial Revolution* – Coal was first used in the small-scale manufacture of goods in the time of the Stuarts, and by the end of the seventeenth century about three million tons a year were being mined. After the invention of the steam engine, coal was used to provide the power for mills and factories. In the form of coke it was used to extract iron from iron ore, and the iron, in turn, was used to make machinery. The combination of mechanical knowledge and a lot of coal made possible the industrial revolution of the nineteenth century; thus Britain became a great industrial power. The United States and many countries of Western Europe also became great industrial powers helped by their large supplies of coal.

During the nineteenth century coal production in Britain rose to about 170 million tons a year, to meet the huge demands both of industry and of transport (ship and locomotive). The greatest amount ever mined in a year was 287 million tons in 1913, and by that time over a million men were employed. The great rise in production meant a big difference to the miners' way of living. They had to leave their villages and move towards the coal-bearing areas. There they lived together in mining communities which were often separate from the rest of the people.

*Working conditions* – Despite the growing prosperity of the mines, the conditions in which the miners worked were often intolerable. Women and children slaved for long hours underground and a good deal of discontent grew up between the miners and their employers. It was not until 1842 that the Shafesbury Act was passed forbidding the employment in mines of women and of children under ten.

In 1919, immediately after the first World War, a government commission under Lord Sankey actually recommended that the mining industry should be taken over by the Government, or nationalized, but this advice was disregarded. In the

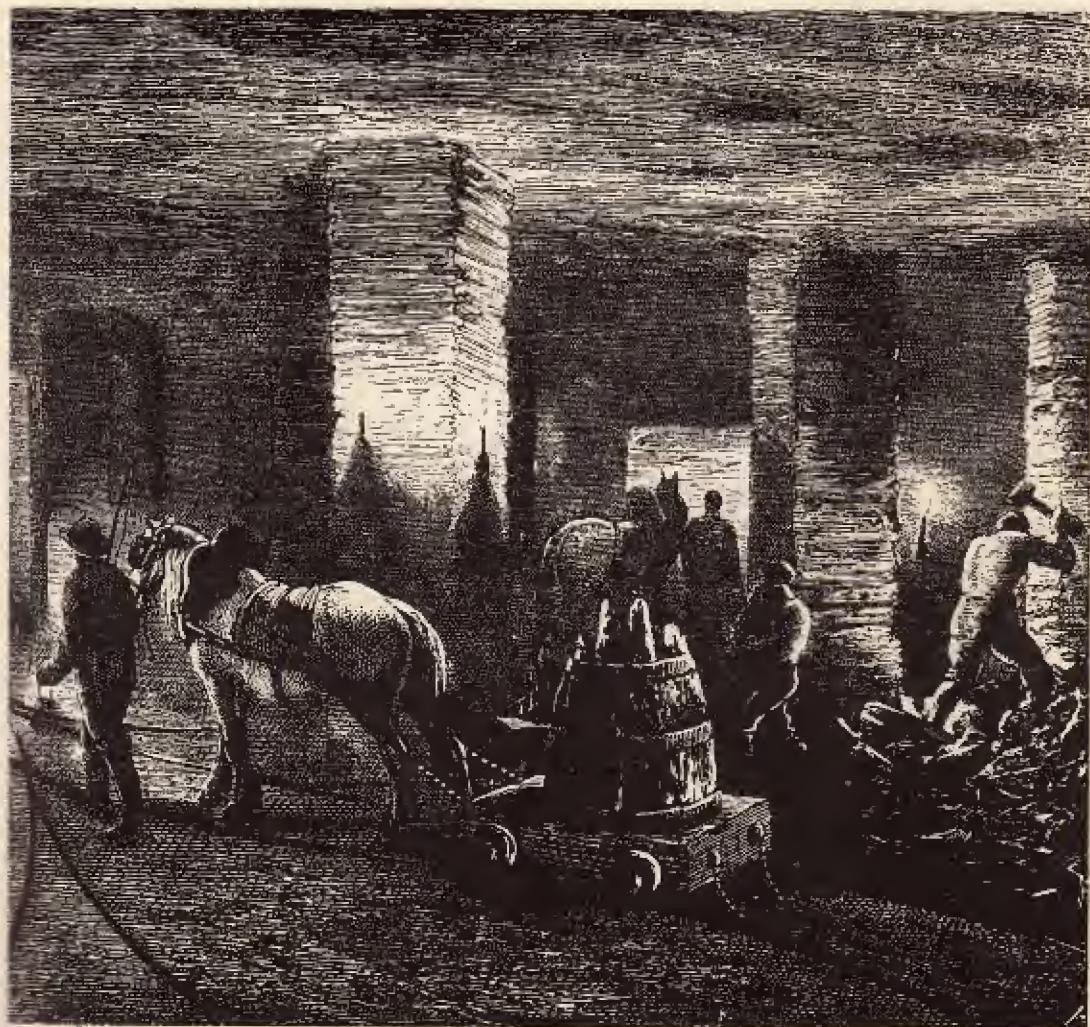


Before the Shafesbury Act of 1842, women and children often carried the coal from the coal-face to the mine shaft.

event, the industry was in for hard times. Because of the disruption of international trade after the war, the demand for coal from British mines fell drastically, and there was much hardship. Discontent among the miners was one of the chief causes of the General Strike in 1926, when the whole of British industry was brought to a halt for the best part of two weeks. The second World War postponed further changes until 1947 when the coal industry was nationalized.

*Mining dangers* – In the nineteenth century mining accidents

were common, and men were killed by large explosions and fires. Mine lighting was poor, men suffered from lung diseases caused by dust, and poor ventilation allowed 'blackdamp' to form. Blackdamp is a mixture of carbon dioxide and nitrogen which can suffocate a man. 'Firedamp', however, is the really dangerous gas in coal mines. This is the gas called methane which is formed during the slow change of vegetation into coal. As the pits became deeper, and ventilation more difficult, so firedamp became more dangerous. The gas escapes from some seams when the coal is being cut, and it can cause



Throughout the nineteenth century, coal production rapidly increased to meet the demands of the industrial revolution. Here is a mine of that period in South Staffordshire. In present-day pits, pit ponies are still used to haul the tools and machinery, but coal is now hauled by small locomotives or carried on conveyor belts.

an explosion when there is between 5 and 15 per cent in the air. It is now sucked from the mine galleries and discharged at the surface.

Sir Humphry Davy is usually associated with the invention of the miners' safety lamp, but George Stephenson and Dr William Clanny also worked on the same problem. Davy discovered that flame from a lighted wick would not escape and fire the gas if it was surrounded by a metal gauze – because the metal gauze conducts away the heat of the flame. Experiments with this lamp were carried out in January 1816. The first

miners to see it were frightened by what seemed to be a naked candle light in the pit. But in reality Davy's invention made mines safer because it improved mine lighting and so helped the miners to carry out their dangerous work.

Carbon monoxide is yet another gas which is a hazard in the mines. It is usually formed after a fire or an explosion and is very difficult to detect because it cannot be smelt. This is why mine rescue workers wear oxygen masks.

Even more dangerous than gas in the mine is falling rock which can trap or kill the miners. Nowadays, mines are in-

The lighting of mines originally presented a problem – because of the danger of explosive gas. The speed lamp (on the left of the photograph) did little to solve the problem – it produced a spray of sparks but was neither safe nor effective. Sir Humphry Davy is usually credited with the invention of the miner's

safety lamp (about 1815), and it is evident, from comparing modern versions of the lamp (on the left) with earlier versions (on the right), that the pattern has hardly changed. Nowadays, however, miners' helmets incorporate an electric light, and the safety lamp is used solely for gas detection.



spected during every shift to ensure that the roof is properly supported and to look at the rock strata for possible faults. But often these faults are difficult to detect, even with the most up-to-date equipment.

*Mechanization of the mines* – The coal-mining industry has been called the cradle of mechanical invention. The first mines were small holes in the ground. The coal was carried out on the backs of women and girls, and later in wooden wheelbarrows and sleds drawn by ponies. As mines became deeper



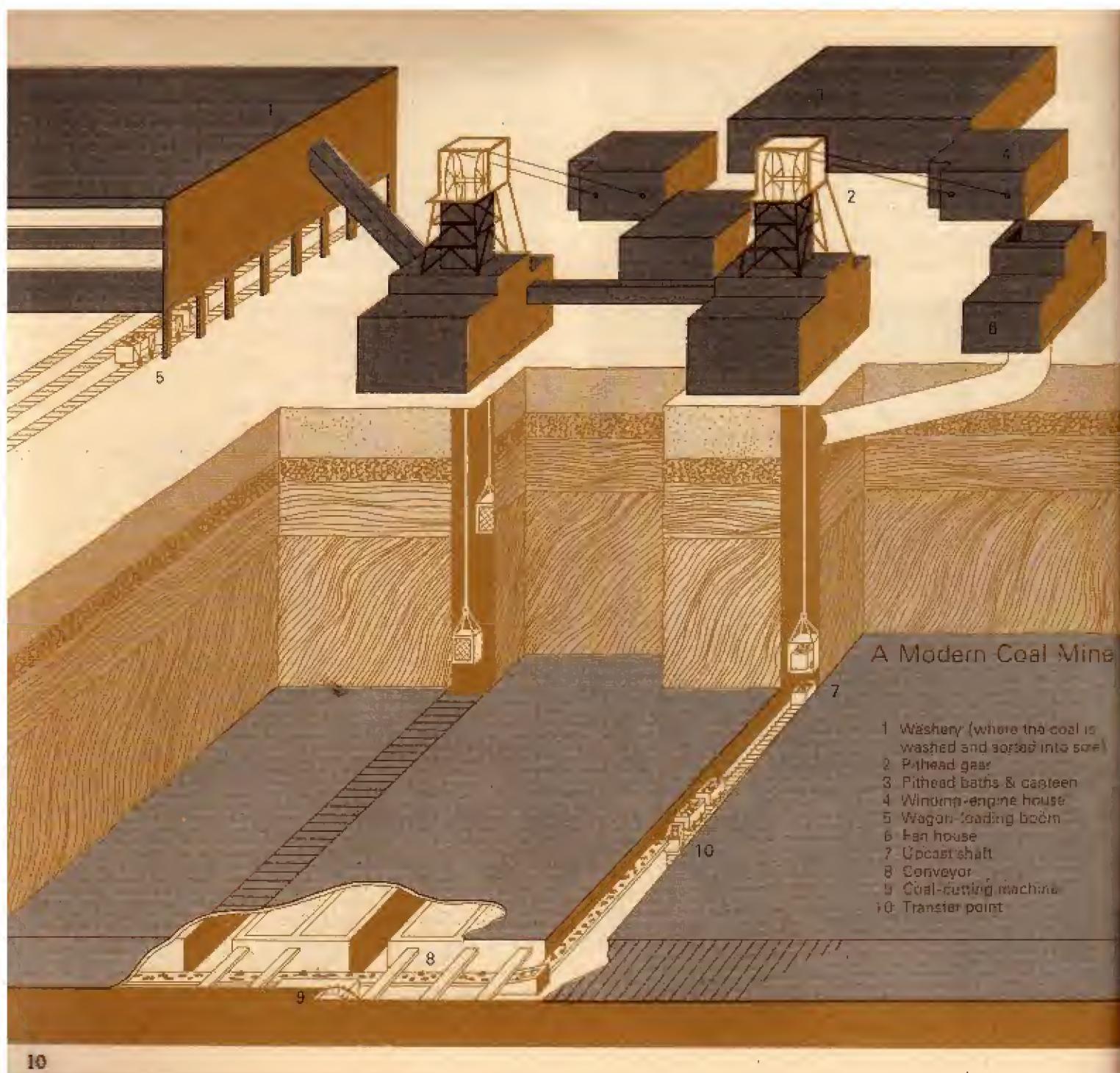
Before proper ventilation was introduced, the 'pennant' (or 'fireman') got rid of the gas in the mines by igniting it. His job, as you may imagine, was not a popular one.

the miners were troubled by water. The problem of draining shallow mines was partially solved by the invention, in 1698, of Savery's 'Miners' Friend', an engine which could suck up water from about 30 feet down. Savery's invention was improved by Newcomen, whose first engine, still using suction but with a piston to work a pump at the shaft bottom, managed to raise water from the much greater depth of 150 feet at Griff Colliery, in Warwickshire. Later, James Watt introduced greatly improved steam engines for pumping.

Progress, too, was made with winding engines. Hand windlasses were used first; they were succeeded by ones worked by horses and, after the development of the crank, by steam-driven rotary engines. Wire ropes appeared towards the middle of the nineteenth century. The ropes were curled round a large drum and passed up through the wheels on the top of the pithead – still a familiar sight in colliery districts.

*Ventilation* – Making the air in the mines fit to breathe was also a great problem. Up to the eighteenth century, the fresh air was allowed to flow naturally down one shaft, pass through the workings, and escape through the upcast shaft. It did not always do so, and it did not always clear the gases that collected. One way of getting rid of the gas was to burn it. This could sometimes be done without disaster because methane is not as dense as air, so that it collects in a layer of pure gas, too rich to explode, lying against the roof of a gallery. A 'fireman', as he was called, would soak his clothing with water and enter the gas-affected area. He would lie flat on his face, holding a lighted candle over his head, and light the gas so that the flame passed over him. Another way of removing gas was to light fires in the upcast shaft: the warm air rose and carried the gases up with it. Both these dangerous methods were superseded by the installation of large fans in upcast shafts to suck the air through the mine and draw it to the surface.

*Getting the coal* – Such technical improvements as the invention of engines for pumping out water and for winding and hauling coal to the surface had made deep mining possible. But there were few improvements in the actual process of getting the coal from the seam until the late nineteenth century when coal-cutting machines began to appear. Miners had always undercut the coal in order to make it fall, and then had broken down the remaining coal with their picks. This is





above

At the surface of an up-to-date mine — Hem Heath Colliery, near Stoke-on-Trent. Apart from the pithead winding gear, above the access shaft to the coal seams, it looks like a well-laid-out factory.

above right

In this well-lit mine roadway at Bettehanger Colliery in Kent, tubs of coal are hauled to the shaft bottom by battery-driven locomotives.

right

Machines, both for cutting and loading the coal, have done much to speed up production. Here a machine called a 'shearer-loader' is cutting through the coal-face — at Kirkby Colliery in the East Midlands. Notice the hydraulic pit props.



like cutting down a tree by striking at its roots. When coal-cutting machines were introduced, this method was imitated, and the machines were designed to cut a long thin slice at the bottom of the seam. Explosives were then placed along the slice to make the coal fall. The early explosives caused many deaths, and in 1911 the Government was forced to make laws which forbade the use of dangerous explosives. Another advance was made in 1905 when the first belt conveyor was installed underground.

*The modern mine* — The surface of a modern mine looks no different from a new factory. No smoke can be seen, because winding engines are driven by electric power, not any miners with dirty faces, because they all have a hot shower in pithead baths when they finish work. New shafts have been sunk which are wider and often deeper than the old ones, thus enabling more coal to be won to the surface every day. Bigger main roadways have been constructed underground, and hundreds of locomotives have been installed to bring the coal more quickly from the seams to the pit bottom. Little tubs carrying only 5 cwt have been replaced by mine cars carrying up to 6 tons each, and in many pits the coal is carried all the way to the shaft by conveyor belt. The biggest change has taken place at the coalface where more than four-fifths of the coal is now mined entirely by machine.

New machines called power loaders now both cut the coal and load it. The speed at which the new machines work has meant that wooden and steel pit props, buttressing the mine roofs, have had to be replaced: first by hand-set hydraulic props which yield as the roof presses down and more recently by sets of hydraulic props which can be moved forward by pressing a button. These sets of props — which are like the legs

of a table with bars stretching across the roof where the table top should be — have mechanized the work of setting props and roof bars and made coal-getting a much faster and more highly productive operation. A modern coalface can now yield coal twice as quickly. Mining goes on twenty-four hours a day every day.

The latest achievement in British mining has been the automated coalface. This is worked by a man in the approach road operating an electronic device which moves the coal-loading machine, the roof supports, the armoured conveyor, and the cables which carry the electric power.

#### *Questions*

1. Why did the demand for coal increase so greatly in the eighteenth and nineteenth centuries?
2. How is a mine ventilated? Draw a diagram to show how fresh air is drawn in and stale air pushed out.
3. Can you think why it is better for pit props to 'give' a little, and where the idea of hydraulic pit props came from?

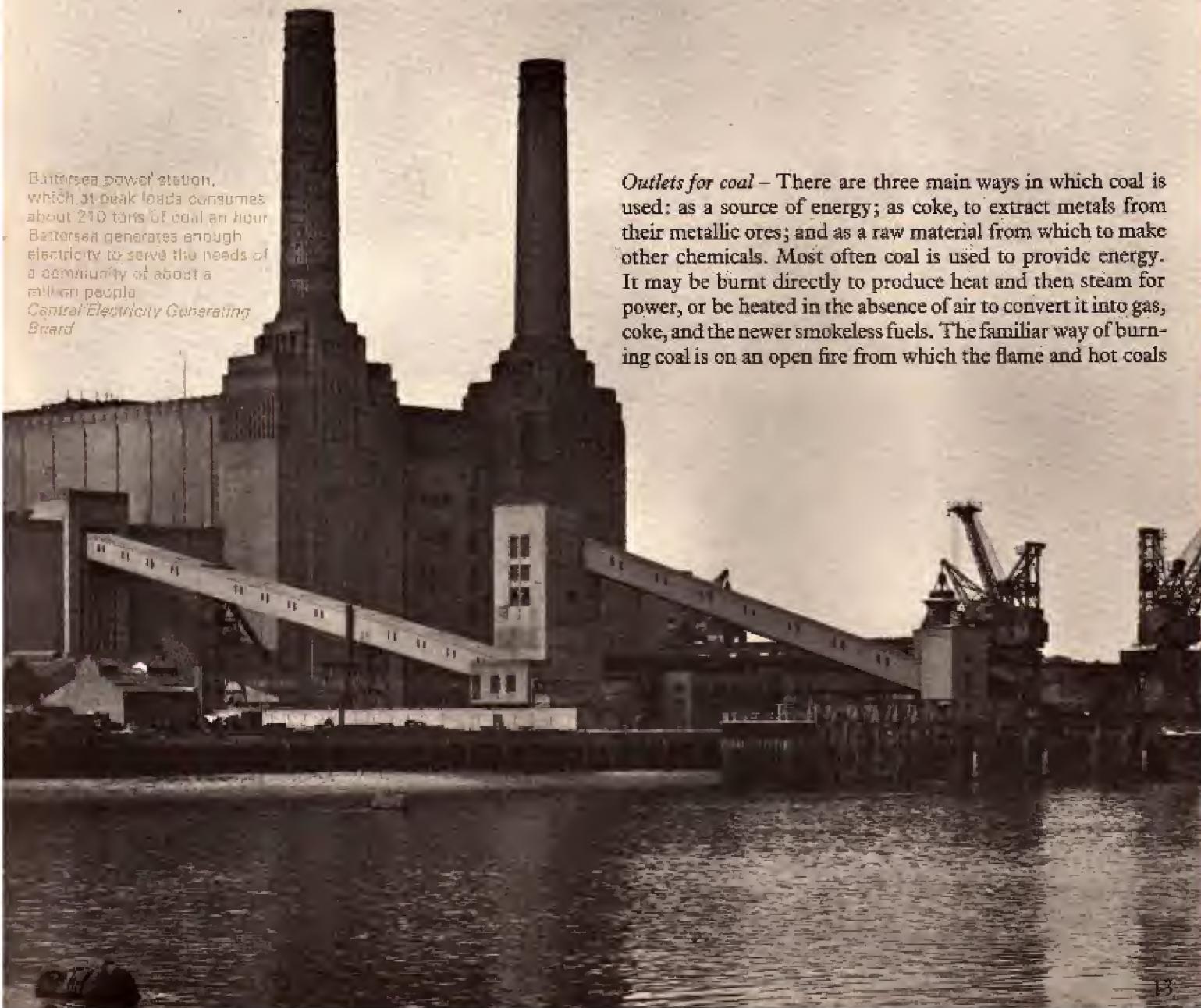
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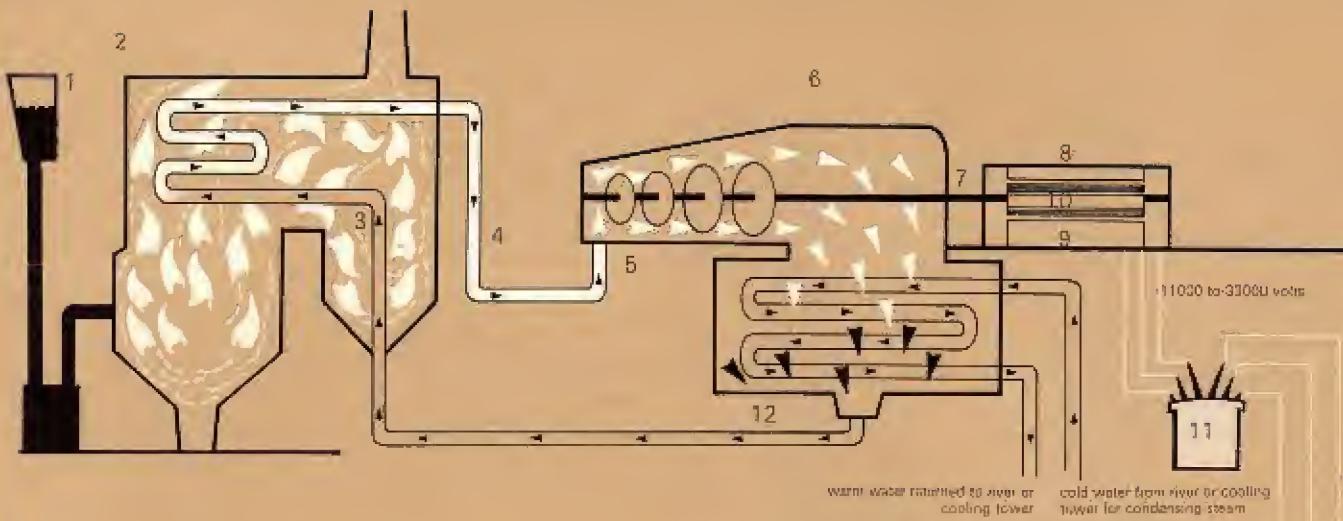
## How coal is used

Battersea power station, which at peak loads consumes about 210 tons of coal an hour. Battersea generates enough electricity to serve the needs of a community of about a million people.

Central Electricity Generating Board

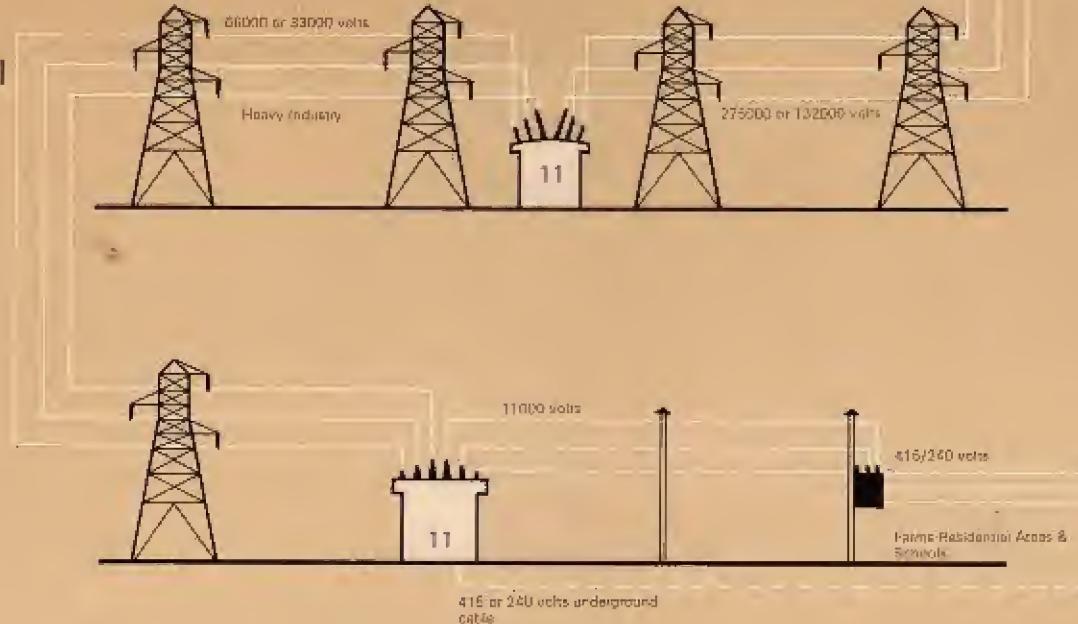
*Outlets for coal* — There are three main ways in which coal is used: as a source of energy; as coke, to extract metals from their metallic ores; and as a raw material from which to make other chemicals. Most often coal is used to provide energy. It may be burnt directly to produce heat and then steam for power, or be heated in the absence of air to convert it into gas, coke, and the newer smokeless fuels. The familiar way of burning coal is on an open fire from which the flame and hot coals





## Electricity from Coal

- 1 Coal
- 2 Furnace
- 3 Boiler Tubes filled with water
- 4 High-pressure steam
- 5 Turbine Blades rotated by steam
- 6 Turbine
- 7 Turbine Shaft
- 8 Generator
- 9 Fixed Coils
- 10 Rotating Magnet
- 11 Transformer
- 12 Condenser



A fuel analyst measures the calorific value of coal. A measured amount of coal powder is put into the bomb (which the analyst is holding), the bomb is placed in the large metal calorimeter, the coal is ignited electrically, and the temperature rise of the water in the calorimeter is measured. The thermometer is in the top left hand corner of the photograph.

provide direct heat. However, much of it is burnt under boilers which range in size from small household models heating water for washing-up to mammoth power-station boilers where steam is generated for making electricity. A household boiler may burn about 1 cwt a week of anthracite or coke, while a power station boiler might burn 20,000 tons a week. In Britain more coal is used for making electricity than for any other purpose.

*Calorific value and chemical composition* – When coal is used for the heat it gives off on burning, the most important thing to know is how much 'heat energy' it can provide. This is called the 'calorific value' of the coal. A convenient and practical way of finding out the calorific value is to take a known weight of coal and, burning it, see what rise in temperature it will produce in a known weight of water. The apparatus for finding this out is known as a *Bomb Calorimeter* and is about the size of a bucket. Right in the centre is the 'bomb' itself, which is slightly larger than a tumbler and which is not intended to explode – in fact it has to be strong enough to make sure it does not explode. About a gram of finely powdered coal, after accurate weighing, is put inside the bomb along with sufficient oxygen at high pressure to ensure that all the coal is burnt when electrically ignited. Nothing can escape from the bomb except the heat which flows out through the walls into the surrounding water. The rise in temperature of this water is measured. Knowing how much fuel heat is required to do a particular job of work, the combustion engineer can work out from the calorific value of the coal he is using how much coal he needs. In Britain, the unit of heat used by engineers is the British Thermal Unit. One British Thermal Unit (Btu) is the amount of heat required to raise the temperature of 1 lb of



Industrial boiler at a factory. These boilers generate steam which is used in the manufacturing process and to produce hot water to keep the factory warm. Working at full power one of these boilers uses up 24 tons of coal a week.



water by 1 degree Fahrenheit. This unit is 252 times as large as the calorie, the heat unit most commonly used by scientists, which is the amount of heat required to raise the temperature of 1 gram of water by 1 degree Centigrade.

It is also important to know the chemical composition of coal and so to calculate how much air is required for combustion. Carbon and hydrogen are the most important constituents of coal. Carbon burns to form carbon dioxide, and hydrogen burns to form water.

To analyse the coal, a weighed amount is burnt, and the weight of carbon dioxide produced is found by absorbing the gas in sodium hydroxide. The water produced comes off as steam which is condensed on a cold surface and weighed. The amounts of carbon and hydrogen in the coal are calculated from the quantities of carbon dioxide and water produced. Fuel laboratories perform hundreds of these analyses every day; their equipment is complicated but the principle is generally the same.

Once the chemical composition of a coal is known, its calorific value can be found not only by experiment using a bomb calorimeter but also by calculation, because every pound of carbon in coal gives out 14,450 Btu on burning, and every pound of hydrogen gives out 61,490 Btu. (These figures are equivalent to 8,080 calories per gram of carbon, and 34,160 calories per gram of hydrogen.)

Many determinations of this kind have to be made because coals from different places differ one from another; there are many thousands of different types throughout the country, although the coals in one area have much in common. The older coals have, in the course of time, lost most of the hydrogen originally present in the vegetation from which they were formed – it probably turned into methane. British coals range

from anthracite in Wales, containing 95 per cent carbon and 2.8 per cent hydrogen, to young coals in the Midlands with 78 per cent carbon and 5.6 per cent hydrogen.

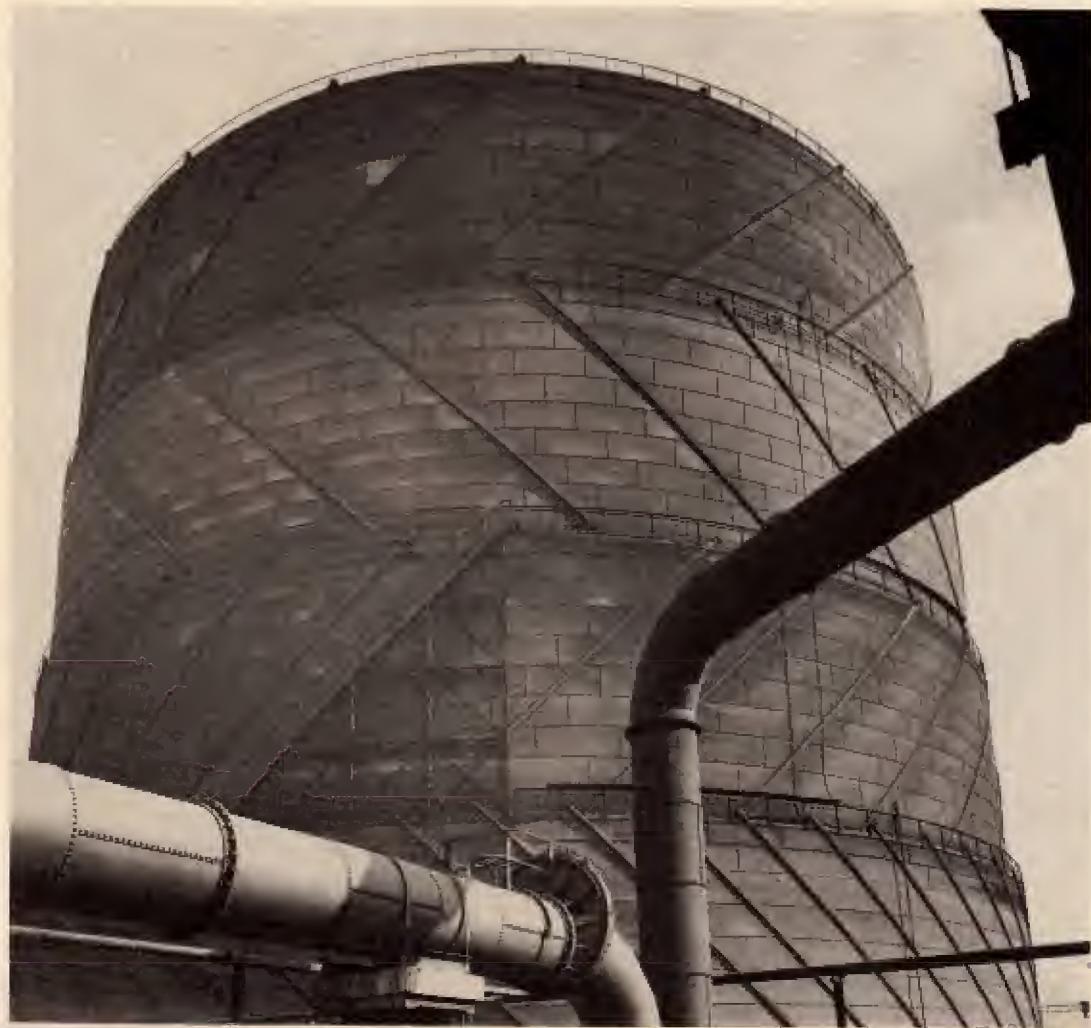
*Burning coal* – When coal is burnt in a boiler, carbon dioxide and water are produced. But the way in which these combustion products are got rid of depends on the size of the boiler. With domestic boilers, the air is pulled through the firebed by the suction of the chimney; the hot gases rise up the chimney because they are less dense than the surrounding air. The same happens with smaller industrial boilers, such as are used in office blocks, hospitals, laundries, and factories. With larger boilers, however, the chimney would have to be too high and the flue gas too hot (which wastes heat) to create the draught needed. So fans are used, as in a vacuum cleaner or paint sprayer, but they are much larger. One fan pushes air into the furnace; another pulls out the flue gas and pushes it up the chimney. The only thing the chimney has to do is to discharge the gases at a sufficient height for the wind to blow them away. The bigger boilers, too, have mechanical stokers for replenishing the coal. Some of the stokers look like conveyor belts with holes: coal goes in one end, is burnt, and the ash falls off at the other. For even larger plants, such as power stations, the coal is ground as fine as face powder and is blown into the boiler furnace where it burns like a gas flame.

*Gas and coke* – Gas was first made and used for gas lighting 150 years ago, when the inventors, James Watt and William Murdoch, first put into practice the earlier discovery in 1688 by Dr John Clayton that coal gave off gas when it was heated. When coal is burnt on a fire, the gas burns making flame, but when the coal is heated out of contact with air, then the gas

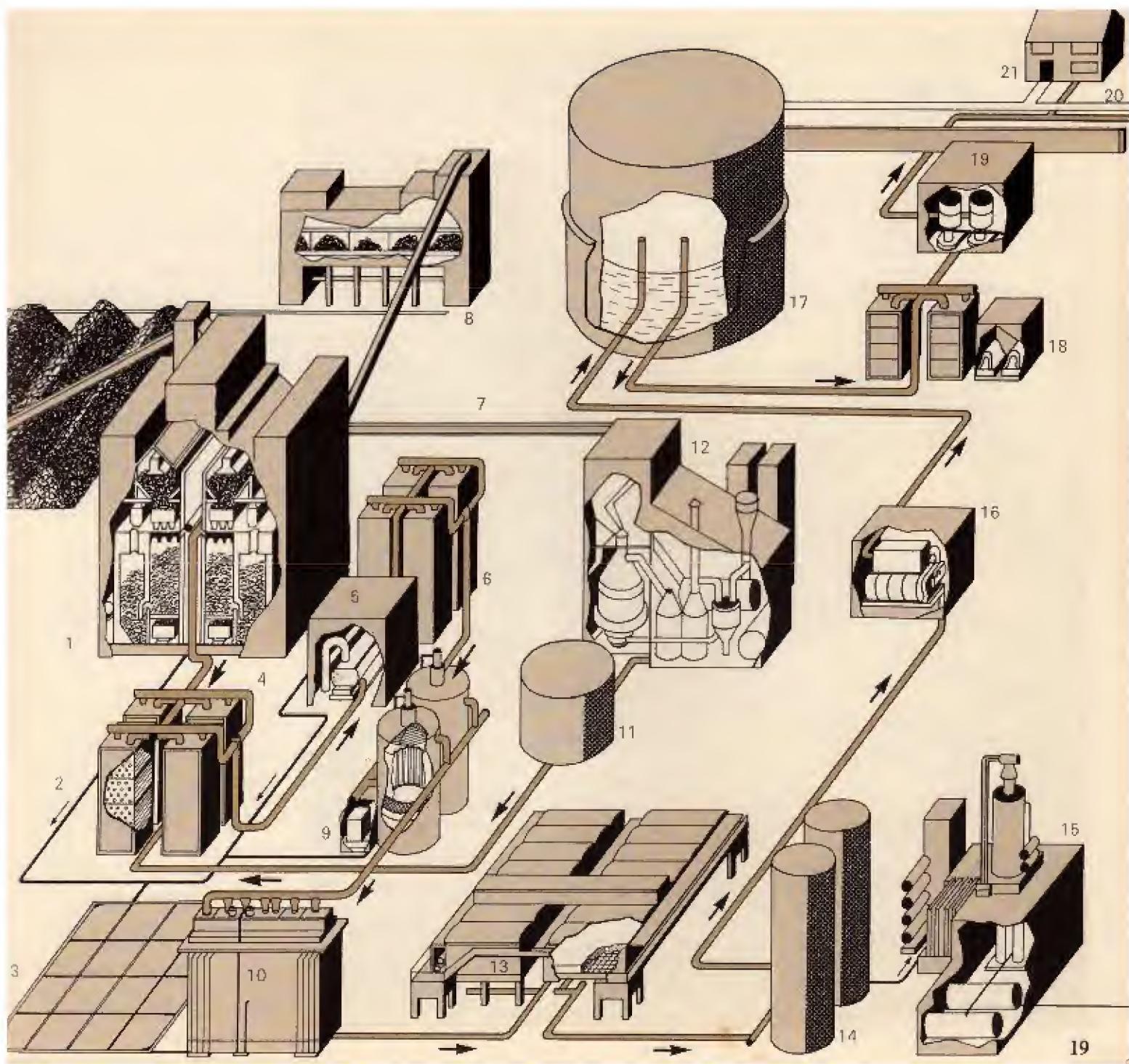
## Gas from Coal

A gas holder at Bunkton Gas Works (the biggest gas works in the world) in the East End of London. The capacity of the holder is  $7\frac{1}{2}$  million cubic feet — enough to serve about 300 homes for a year.

North Thames Gas Board



- 1 Burnt house where coke is baked in ovens
- 2 Tar being piped off
- 3 Wall for tar storage
- 4 Primary condensers (main coolers)
- 5 Exhaustor which draws off gas
- 6 Condenser for further cooling
- 7 Coke to water-gas plant
- 8 Coke graving plant
- 9 Last-oil-tar separator
- 10 Washer where ammonia is removed (by dissolving it in water)
- 11 Balance holder to control supply of gas
- 12 Carbonated water-gas from steam coke and oil
- 13 Purifiers for clean flame and so on
- 14 Benzene recovery plant
- 15 To refinery
- 16 Station meter (or measure)
- 17 Gas holder
- 18 Gas dryer — washing it has left it wet
- 19 Pressure governor to control supply
- 20 Street main supply pipes
- 21 House supply





a strong coke for use in blast furnaces is specially prepared in coke ovens. Here, glowing coke is being discharged from an oven into a coke-car. The car carries the hot coke to a quencher, where it is doused with water, and then discharges the coke down the chute.

Tar, a by-product from distilling coal, being used to surface a road  
*North Thames Gas Board*



can be collected, piped away, and burnt when needed. Originally, gas-making plants were installed at factories to provide a new and, for those days, powerful form of lighting. The earliest plant was installed in 1805 at a Manchester cotton mill. Shortly after this, in 1808, gas was used for street lighting in Pall Mall, London, and later elsewhere. Gas has to be distributed in pipes which do not leak, and some of the earliest gas pipes were made from government-surplus gun barrels left over from the Napoleonic wars. The first 'barrel' pipes were clamped together; later ones were joined by screw threads. Even today, steel piping for gas (and for water) is still called 'barrel'. Supplies of gas, pressurized to form a liquid, can also be carried about in cylinders or tanks. A small quantity of liquid gives a very large quantity of gas.

Gas has been made in many ways, but the gas industry now makes most of its coal gas in vertical retorts. These are special tubes of a silica material, usually about two yards across and five yards high, down which coal passes and is heated to white heat from the outside by burning gas. Six or eight retorts together make a bench, and several benches make a battery. When heated, solid coal splits into two parts: the volatile coal

gas (consisting of hydrogen, methane, and carbon monoxide) plus several liquids (such as benzole and tar); and coke, which is a form of carbon. The gas is gently drawn from the top, cooled, purified, and sold as town gas; the coke is removed from the bottom, cooled, sorted into different sizes, and sold for household use.

The gas industry 'carbonizes' coal mainly for the gas - coke is a by-product. The iron and steel industry does the same thing mainly to make a strong coke for use in blast furnaces. To make coke, the iron and steel industry uses coke ovens which are tall thin chambers half a yard wide, about 4 yards high, and 12 yards long. These ovens are set side by side, interleaved with spaces through which white-hot burning gas can pass for heating purposes. They look like a pile of sandwiches on edge. Coal is put into the ovens from the top and is left to heat up. When the gas has all come off, the tall thin doors at the front and back of the oven are taken off and a large ram pushes out 15 tons of glowing coke into a coke-car. The coke-car runs along rails to a tower which has water sprays to cool the coke and prevent it burning in the air. The coke is then separated into different sizes, and is used in blast furnaces to extract iron from iron ore. Much of the gas is cleaned, purified, and sold, just as in a gas works.

*By-products of coal* - The making of gas and coke by heating coal produces some very useful by-products, hydrocarbon liquids such as benzene and tar, and also ammonia. These liquids all condense from the gas as it is cooled. The benzene is added to gasoline to make it work better in car engines. Tar is used for road-making, creosote (from distilling tar) for preserving wood (telegraph poles, railway sleepers, and garden fences), and ammonia is used to make fertilizer. Naphthalene and other chemicals can be extracted from tar and used as the starting materials for making a number of useful substances. Weed-killers, dyes for clothes, the mysterious stuff in detergents that make clothes seem bright, plastics, medicines, water softeners, and many other things can all come from coal in this way.

*Domestic fuels and smoke* - If coal is burnt properly and completely, as in industrial boilers, there need be no smoke. But it is difficult in most fireplaces and kitchen boilers to burn coal smokelessly unless special care is taken. Therefore smoke-

## By-products of Coal

Some of the many useful things that can be made from coal and its by-products.

iron smelting

industrial and domestic heating



coke



gas

benzole

xylene



benzene

xylene



ammoniacal liquor



tar



toluene

light oils

anthracene oil

naphthalene oil



photographic chemicals



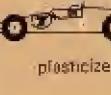
drugs



dyes



road tar



plasticizers



fire-lighters



pesticides

pitch

creosote oils

carbolic oil



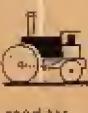
small coal coking



roofing



roofing



road tar



fruit tree sprays



fuel oil



wood preservatives



phenol plastics



disinfectants



explosives



weed killers

less fuels like coke are very useful. Normal coke is a simple type of smokeless solid fuel, and there are other smokeless fuels made by special processes. For example, coal dust is heated to drive off the smoke, and then the residue (known as char) is squeezed to make smokeless briquettes.

*The future of coal* – About four-fifths of the coal that is mined in Britain is used directly for the heat it contains. The remaining fifth is turned into gas and coke, which are also burnt, and by-products. What does the future hold?

First, the requirements of the customers will alter. Electricity will need larger and larger amounts, and may eventually take about half the coal mined each year. Gas works will use less because oil processes for making gas are becoming more popular. Coke-ovens will use less if the public prefers the new smokeless fuels to coke, but more if engineering and ship-building works require more iron.

Second, coal will be used in different ways. New ways will be found of turning it into gas, electricity, and chemicals. Another interesting new use for coal is to grind it and force it into blast furnaces making iron. This increases the heat of the furnace and makes iron extraction more efficient. Research is continually leading to new and better methods of using coal.

#### Questions

1. Of all types of work to do with coal – mining, gas- and coke-making, electricity-generating, making chemicals from by-products, selling, and research into all of these – which would you most like to do and why?
2. If a Nottingham coal contained 80 per cent carbon and 5 per cent hydrogen (the other 15 per cent being mainly oxygen and nitrogen), how many heat units would 1 lb give out when burnt? Express your answer both in British Thermal Units and in calories.
3. How does coal drive a steam engine?

"Phurnacite" – a smokeless boiler fuel – leaving the manufacturing plant.





Transporting coal

By train



By ship

*Unless otherwise stated, all photographs in this book have been provided by the National Coal Board.*

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